TRIALS ON THE USE AND EFFECTIVENESS OF ARTIFICIAL NEST HOLLOWS FOR CARNABY'S COCKATOO AT CATABY, WESTERN AUSTRALIA

By R.E. JOHNSTONE[1], T. KIRKBY[1] and M. MANNION[2]

[1]Department of Ornithology, Western Australian Museum, Locked Bag 49, Welshpool DC, Western Australia 6986

[2] Iluka Resources Limited
140 St Georges Terrace, Perth, Western Australia 6000

INTRODUCTION

The loss of hollow-bearing trees in the Western Australian wheatbelt is one of the most important factors to overcome in fauna conservation. Apart from the dwindling supply of hollows in some landscapes, obligate hollow users must also compete with a number of pest and competitor species including the introduced feral European Honeybee (*Apis mellifera*) that is infesting hollows of all sizes throughout the entire south-west region at an increasing rate.

The use of artificial nest boxes, pipe or tube hollows and modified nest logs has been used successfully for the recovery of Glossy Cockatoos (*Calyptorhynchus lathami*) on Kangaroo Island and for Carnaby's Cockatoo (*Calyptorhynchus latirostris*) in parts of the Western Australian wheatbelt. Artificial nest hollows are not the panacea to loss of natural hollows and can be relatively expensive to erect and monitor. They are also subject to occupation by feral Honeybees as well as aggressive native competitor species such as Galahs and Corellas which have become superabundant in many areas of the south-west region in recent times.

Since 2000 we have been conducting ongoing experimentation with timber nest boxes and poly pipe (PE pipe) or tubes (Cockatubes®) at a number of sites in the south-west. Our main aim was to increase nest sites for black cockatoos with the provision of artificial nest hollows, especially in areas where hollows were limited and there was extensive competition for nest sites. The development of artificial hollows that were suitable for cockatoos, but unsuitable for bees and invasive native competitor species *viz.* Galahs and Corellas, was a high priority as was the development of protocols for the use and installation of these hollows. The installation of timber nest boxes and poly tubes was done in conjunction with repairing substandard and damaged hollows in the study area. In extreme cases this required extensive re-

building natural hollows previously used by cockatoos (i.e. repairing walls of hollows, fixing collapsed floors and removing fallen branches that had blocked the entrance etc.).

Recent research at one of our monitoring sites (Cataby in the Shire of Dandaragan, 164 km north of Perth) into the type, size, shape and placement of artificial nest hollows has led to a much better understanding of materials and designs that are most successful for Carnaby's Cockatoo and what types are best to discourage introduced feral and pest species from using the hollows.

Most of the research reported here was undertaken with funding by Iluka Resources Limited to satisfy part of the conditions required to allow implementation of the Carnaby's Cockatoo Management Plan presented in the *Cataby Mineral Sands Project, Environmental Protection Statement* (November 2005).

CATABY–DANDARAGAN LANDSCAPE

In the Cataby–Dandaragan area, as in other parts of the wheatbelt, there has been considerable habitat fragmentation with the clearing of most of the native vegetation which has altered the once extensive woodland landscape into a fractured one, consisting of remnants of native vegetation, isolated trees in paddocks, narrow streamline strips of vegetation (e.g. along Cataby and Minyulo Brooks) and narrow roadside verges among a vast area of cleared farmland. As a consequence of the process of habitat fragmentation many wheatbelt remnants such as at Cataby (Oliver Remnant) provide significant breeding habitat for hollow-nesting birds.

IMPACTS OF FERAL HONEYBEES AND PROBLEM NATIVE SPECIES

In this mid-western wheatbelt region Carnaby's Cockatoo competes for use of hollows with the Galah *Cacatua roseicapilla*, the Western Long-billed Corella (Butler's Corella) *Cacatua pastinator butleri*, also several duck species (mainly Australian Shelduck *Tadorna tadornoides* and Australian Wood Duck *Chenonetta jubata)* and the introduced European Honeybee. There has been a dramatic expansion in the distribution and status of Galahs and Western Long-billed Corellas in this region in the past forty years (see Johnstone and Storr 1998). In the Cataby area for example both species were listed as scarce or absent in the late 1970s and early 1980s. The massive range expansion and increase in abundance of these birds has led to competition for nest hollows with Carnaby's Cockatoo.

Both Galahs and Corellas begin breeding before the migratory Carnaby's Cockatoo return to the breeding site and Galahs also

maintain a continuing attachment to their nest hollow (and sometimes other hollows nearby) throughout the non-breeding season. Galahs also scar and eventually ring-bark and kill trees and, like Corellas, will also remove eggs and chicks of other species from hollows.

Our study site at Cataby also clearly highlighted the enormous problem of the feral European Honeybees taking over hollows in this region. We located over 200 feral beehives in a narrow 3 km stretch of Wandoo woodland along the Cataby Brook. Many of these are in hollows that have been previously used by Carnaby's Cockatoo and other birds. For impact of feral European Honeybees on black cockatoos see Johnstone and Kirkby (2007).

The 2004 Cataby survey located 24 hollows used by Carnaby's Cockatoo, 84 used by Galahs, 37 used by Long-billed Corellas and 8 used by ducks. This site was clearly very suitable to assess the impacts on Carnaby's Cockatoo from competitors, especially Galahs and Corellas, to look at hollow decline and to trial artificial nest hollows to see if it was possible to reduce competition for nest hollows.

CATABY STUDY

In 2004 we began to trial a small number of artificial nest hollows to determine which designs would be suitable for Carnaby's Cockatoo but generally unsuitable for Galahs, Corellas and feral Honeybees within the Cataby Brook area. On 7 August 2004 we erected four artificial nest hollows within the Carnaby's Cockatoo breeding area of Oliver Remnant (an area of mostly Wandoo *Eucalyptus wandoo* woodland) along Cataby Brook. Two of these (nest numbers 357 and 360) are large PE, top entry poly pipe hollows (see details below) and both were erected in the main trunks of large Wandoo trees with burnt out tops (chimney stack type trees). A large wooden, top entry nest box (nest number 358) was erected 8.3 m up in a large Marri *Corymbia calophylla* growing at the edge of Cataby Brook and a smaller wooden side entry box (nest number 359) was erected 7 m up in a Wandoo also at the edge of Cataby Brook.

In August 2005 nest box 359 that had been quickly taken over by Galahs (see below) was removed, repaired and altered into a top entry box and in 2006 was re-erected (as nest number 069) 7 m up in a Wandoo.

In September 2007 we erected a third PE nest pipe (nest number 441) in Wandoo (near Oliver's Homestead) giving a total of five artificial hollows that have been monitored each year to the present 2014.

DETAILS OF ARTIFICIAL HOLLOWS

Two wooden nest boxes were trialled and are described below.

A large wooden box nest 358 (Figure 1) made with exterior grade plywood and measuring 750 mm high-deep, with a sloping hardwood spout 320 mm high at back to 50 mm at front (see figure 1) giving a total depth of over 800 mm, with circular 170 mm diameter spout entrance on a hinged lid, rectangular box 400 *x* 300 mm. All inside walls were lined with 10 mm square heavy gauge mesh to prevent birds chewing through the sides and allows birds to climb to entrance. All outside corners are protected by 20 *x* 20 mm aluminium angle which prevents destruction from outside. A small observation panel is provided on one side with a galvanised plate held in position with a Tek screw. The boxes were painted with Gripset, a bitumen rubber sealant (adhesive coating, water-based, non-flammable, non-toxic, free of solvents and dangerous fumes, and UV resistant) including the inside floor to help with waterproofing.

Figure 1. Nest 358 – large wooden box

Figure 2. Nest 069 (formerly 359) – small wooden box

A small wooden box nest 359 (Figure 2) constructed from exterior grade plywood with a hardwood spout side entry. The internal chamber size is 650 mm high-deep, square 240 *x* 240 mm,

with floor space 350 mm diagonally, and side spout with 200 mm diameter entrance. The interior wall is lined with 10 mm square galvanised mesh and outside corners protected by 20 *x* 20 aluminium angle. A small observation panel is provided on one side with a galvanised plate held in position with a screw. The wooden base was sprayed with Citronella oil to deter feral Honeybees.

Three Medium Density Polyethylene (MDPE) or PE tubes (poly pipe hollows or Cockatubes®), two large one slightly smaller were also trialled and are described below (see Figures 3, 4 and 5).

These PE tubes were specifically designed by R. E. Johnstone and T. Kirkby for black cockatoos based on measurements of hundreds of natural hollows used by all three species of black cockatoo in the south-west.

PE industrial pipe is used by mining companies with off-cuts and old sections of pipe being readily available. The length of pipes used ranged from 0.8–1.2 m, the external diameter ranged from 350–400 mm and the internal diameter 300–350 mm.

The PE tube orientation is for vertical top entry as all black cockatoos back into hollows and this makes the tubes attractive for Carnaby's Cockatoos, but

Figure 3. A: Nest 357 – PE pipe. **B**: Nest 357 with breeding pair.

Figure 4. Nest 360 – PE pipe

Figure 5. Nest 441 – PE pipe

unattractive to feral Honeybees and competitor species i.e. Galahs and Corellas that prefer dark hollows.

Internal access is provided by a galvanised weldmesh or other heavy wire mesh internal ladder 100 mm wide (about 20–40 mm squares) or heavy chain bolted through the pipe with galvanised gutter bolts.

At least two sacrificial chewing posts ca. 70 x 50 mm of hardwood or sections of hardwood e.g. Wandoo, Marri or Jarrah etc. are fixed to the sides of the internal ladder. The timber was pre-drilled and attached through the pipe with galvanised bolts. These posts were left extending beyond the top of the pipe in order to provide evidence of hollow use i.e. fresh chewing during the breeding season.

The floor was made of heavy duty stainless steel, treated metal, galvanised mesh or thick hardwood timber, shaped to fit internally with sharp or rough edges curled inwards and fixed with galvanised or stainless steel Tek® screws. Holes were drilled around the base for water drainage. The floor space was filled to about 150 mm with wood chips to create a dry egg mat.

INSTALLATION OF ARTIFICIAL HOLLOWS

Both wooden boxes and tubes were attached to trees with brackets, galvanised chain or simply bolted or screwed to tree (if in burnt out trunk) and erected in vertical or near vertical position.

Where possible, hollows were erected facing away from prevailing weather and at a similar height to natural nests. Although these artificial nest boxes and tubes are heavy, they can be lifted into position using a rope and pulley by one person and held in place while being attached. A 4WD vehicle or 'elevated work platform' could also be used to position the hollow.

POSITIONING OF ARTIFICIAL HOLLOWS

At Cataby the hollows were positioned at specific sites in order for us to study not only the uptake of the hollows, but also to look at competition with other species and to determine the use and success rate of different hollow types over a number of breeding seasons. We were also interested in the longevity of the different nests including the sacrificial posts, walls and floors of the hollows.

All the artificial hollows were placed within the Oliver remnant patch of Wandoo woodland in areas where Carnaby's Cockatoo undergo high competition for hollows from feral Honeybees, Galahs and Western Long-billed Corellas (Butler's Corella) and where many pairs were using poor quality or substandard natural hollows i.e. shallow open hollows subject to predation and flooding etc.

The large wooden box, nest 358 (Figure 1), was erected in a large Marri (containing no hollows) at the edge of the Oliver Remnant and about 100 m from the nearest Carnaby's Cockatoo nest but adjacent to several feral Honeybee hives and Corella nests.

The small side entry wooden box, nest 359 (Figure 2), was erected in a tall Wandoo (with no hollows) and between trees with an active Galah nest, a Corella nest and a hollow used by Carnaby's Cockatoo.

The three PE tubes were spread through the breeding habitat and all are close to feral Honeybee colonies.

One large PE tube, nest 357 (Figure 3a), was placed inside a burnt out main trunk of a Wandoo adjacent to another tree that contained a natural nest hollow that was being vigorously fought over by pairs of Corellas and Carnaby's Cockatoos. It is noteworthy that by inserting the tube into the burnt tree trunk of this tree, which is close to a roadhouse and a rest area often visited by general public, it became relatively inconspicuous.

A second large PE tube, nest 360 (Figure 4), erected in another burnt out main trunk of a

Wandoo was close to natural hollows in adjacent trees that were being fought over by both Corellas and Galahs.

A third slightly smaller PE tube, nest 441 (Figure 5), was erected near a small chimney-type hollow in a dead Wandoo (near Oliver's homestead) that had been used by Carnaby's Cockatoo since the 1950s and in more recent times had been used intermittently by Carnaby's Cockatoo and Corellas both with little success.

HOLLOW USE

Nest 358 – large wooden box

In the first breeding season (2004–05) the large wooden box, nest 358 (Figure 1), was quickly taken over by a pair of Carnaby's Cockatoo and they successfully fledged a chick.

In the 2005–06 season the nest was unsuccessful. On 3 September 2005 the nest contained 5 eggs of the Australian Shelduck that were removed, a single Carnaby's Cockatoo egg on 17 September and 9 October 2005, but this egg was addled and rotten by 24 October and although a female Cockatoo was observed in the nest in November and December no further eggs were laid.

In the 2006–07 breeding season a chick was successfully fledged.

In the 2007–08 breeding season the nest was unsuccessful. In September–October 2007, this nest contained a female Carnaby's Cockatoo, but by 15 November the box had again been taken over by an Australian Shelduck and contained five addled Shelduck eggs and an addled Carnaby's Cockatoo egg buried under duck eggs and down.

In the 2008–09 breeding season Carnaby's Cockatoo were successful at fledging a chick from this box.

In the 2009–10 breeding season a chick was successfully fledged.

In the 2010–11 breeding season two chicks were successfully fledged.

In the 2011–12 breeding season the nest box was unused.

In the 2012–13 breeding season a chick was successfully fledged.

In the 2013–14 breeding season the nest was unsuccessful. A female was flushed from the nest on 21 September, also on the 5 October and on the 19 October 2013, so no doubt eggs were laid, but were unsuccessful.

Nest 069 (formerly Nest 359) small wooden box

The small wooden box, Nest 359, erected in August 2004 was quickly taken over by Galahs (prospecting it within hours of it being erected). On 20 August 2005 a female Galah was flushed from the box that contained a single egg and the base of the box had been completely destroyed by the Galahs chewing the timber from both inside and out. It was removed in 2005, repaired and altered into a top entry box (lid removed) making it more

suitable for Carnaby's Cockatoo then re-numbered 069 and erected 7 m up in a tall Wandoo about 100 m away in 2006.

Nest box 069 (the altered 359) was used successfully by Carnaby's Cockatoo in the 2006–07 breeding season with the female using the top entry rather than the side spout. At only 650 mm deep and 240 mm square, this is one of the smallest hollows we have recorded used by Carnaby's Cockatoo.

In the 2007–08 breeding season it was unsuccessful. It contained a female Carnaby's Cockatoo on 22 September 2007, but by 19 October it contained a Corella perched at entrance and Carnaby's Cockatoo eggshells in the box.

In the 2008–09 breeding season it was again unsuccessful due to disturbance by Corellas or Galahs. A female Carnaby's Cockatoo was flushed from the nest on the 25 September and 10 October 2008 and a pair observed on the box on 18 November with the female fighting off Corellas, and a female was flushed to the top entrance of the box again on 12 December, but by 29 December the nest was empty except for feathers of Carnaby's Cockatoo and feathers of Corella and Galah and we believe that the cockatoo eggs were destroyed by the former.

In 2009–10 breeding season it was unsuccessful again probably due to competition/predation by Corellas. A female Carnaby's Cockatoo was observed fighting off Corellas in November 2009.

In the 2010–11 breeding season it was unsuccessful. A female Carnaby's Cockatoo was flushed to the top entrance of the box on 6 September 2010 and on 24 September 2010, but the nest box contained two broken eggshells on 9 October 2010. The eggs were probably broken by Corellas.

In the 2011–12 breeding season it was again unsuccessful due to competition with Grey Teal (*Anas gracilis*). A pair of Carnaby's Cockatoos certainly attempted to breed in the box that season. A male was observed on top of the box on 2 November 2011, a female flushed from the box on 18 November, but by 3 December the two cockatoo eggs were addled and had been covered by Grey Teal feather down and eggs. The nest box had obviously been taken over by the Grey Teal after the Carnaby's Cockatoo had laid eggs.

In the 2012–13 breeding season it was again unsuccessful. A female was flushed to top of box on 6 October 2012, 20 October 2012, and 3 November 2012. The nest contained a downy chick on 17 November, a pin-feathered chick on 1 December 2012, a large feathered chick on 22 December 2012, but a dead fully feathered chick (ready to fledge) on 12 January 2013. This chick probably died due to a week of heat-wave conditions. A number of other chicks in natural hollows at Cataby were lost during the same period.

In the 2013–14 breeding season a chick was successfully fledged.

Since being altered it has been used successfully by Carnaby's Cockatoo in 2 out of 8 breeding seasons and has lost eggs and chicks in other years due to various reasons, but mainly through competition for the hollow from Corellas, Galahs and small ducks which is reflected in the low breeding success rate.

Our plan is to erect a PE tube near this nest for comparison of breeding success.

Nest 357 – PE pipe

The PE pipe nest 357 (Figure 3a) was not used in the 2004–05 breeding season.

In the 2005–06 breeding season it was unsuccessful. A female Carnaby's Cockatoo was flushed from the nest on 20 August 2005; it contained two eggs on 3 September and 17 September 2005, but only the remains of hatched egg shells with both hatchlings missing on 9 October and egg shell found under the tree on 24 October 2005.

In the 2006–07 breeding season it was unused, however, it was regularly visited judging from the extensive chewing on the internal sacrificial posts.

In the six 2007–08, 2008–09, 2009–10, 2010–11, 2011–12 and 2012–13 breeding seasons it was successful fledging a single chick each year.

In the 2013–14 breeding season it was unsuccessful. A female was flushed from this nest on 21 September 2013 and a male was perched near the nest on 2 November 2013, but the nest contained only egg shell remains.

Overall it has been successful (i.e. fledged a chick) in six out of ten breeding seasons.

Nest 360 – PE pipe

Nest 360 (Figure 4) was unsuccessful in the 2004–05 breeding season. An almost fledged chick in this nest was probably taken by a cat judging from fur and feathers near the tree.

In the 2005–06 breeding season it was also unsuccessful. On 20 August 2005 a pair of Corellas that had been prospecting this nest had burrowed under the base of the nest pipe into soft wood debris and a plug of termite workings, creating a tunnel over 30 cm long and by 3 September 2005 had laid eggs in the tunnel. The nest tube contained a female Carnaby's Cockatoo incubating 2 eggs on 24 October 2005 but these eggs were predated on (probably by the Corellas) by 12 November. It is noteworthy that the Corellas found the nest tube unattractive and burrowed under the pipe to create a dark nest cavity, but apparently still competed with the pair of Carnaby's Cockatoos that arrived much later to use the nest. The Corella tunnel or burrow was filled in 2005.

In the 2006–07 breeding season a chick fledged successfully.

In the 2007–08 breeding season it was again unsuccessful. It

contained a female Carnaby's Cockatoo on 19 October 2007; 2 eggs on 15 November 2007, however, the nest was deserted and the eggs rotten and broken by 15 December 2007. A pair of Corellas had once again attempted to nest under the base of the pipe and were probably responsible for the destruction of the Carnaby's Cockatoo eggs.

In the 2008–09 breeding season the nest was unused.

In the 2009–10 breeding season it was unsuccessful. A female Carnaby's Cockatoo was flushed from this nest on 17 October 2009, but no evidence of breeding after that date. A pair of Butler's Corellas was often observed near this nest.

In the 2010–11, 2011–12, 2012–13 and 2013–14 breeding seasons, chicks fledged successfully.

It is noteworthy that although Corellas prospected this nest they found it unattractive and preferred to burrow under the base of the pipe rather than nest in it whereas the pair of Carnaby's Cockatoos has successfully reared a chick from this nest in five out of nine years often with Corellas close by.

Nest 441 – PVC pipe

In the 2007–08 breeding season this nest (Figure 5) was unsuccessful. It contained a female Carnaby's Cockatoo incubating 2 eggs on 19 October 2007; a hatchling and one egg on 15 November 2007, but only the downy remains of a chick on 1 December 2007. It is unknown what caused the death of this chick.

In the 2008–09 breeding season the nest was not used.

In the 2009–10, 2010–11, 2011–12, 2012–13 and 2013–14 breeding seasons, chicks fledged successfully.

DISCUSSION AND RESULTS

These trials have provided valuable insights into the use of artificial hollows, design features, materials used to build them, where they are located and their success rate in an area where natural hollows are at a premium. We are at a time now where there is a critical shortage of suitable hollows for Carnaby's Cockatoo in many areas of the wheatbelt and having an artificial hollow with design features tailored for this species may help retain populations in some of these small patches of remnant woodlands.

Occupation of the wooden nest boxes was very rapid, i.e. within the first year and within hours with the small box, by both Carnaby's Cockatoo and pest species namely Galahs and Corellas, and as expected the competitor species, although smaller, were dominant. Both Galahs and Corellas prefer deep dark hollows and it was noteworthy that ducks also preferred the wooden boxes. The Grey Teal, a relatively small duck preferred the small box and the larger Australian Shelduck the

larger wooden box. None of the PE tubes has been occupied by Galahs, Corellas, ducks or feral Honeybees. The small wooden box 069 was more susceptible to predation being fairly shallow, and at other sites in the south-west boxes such as this one were quickly occupied by feral Honeybees. The base of nest 069 was treated with Citronella oil to deter feral Honeybees and this treatment has proved to be successful during the trial.

Both wooden boxes have required regular maintenance and would have a limited lifespan. The PE tubes also require some maintenance as far as the sacrificial posts are concerned and depending on the materials used would need replacement every 6–10 years. The initial sacrificial posts used in nests 357 and 360 were made from old weathered material and were largely destroyed by the sitting females within two years. These were replaced in 2006 with much harder posts that have remained, more or less intact, up to the present day. The Wandoo posts in nest 441 are still in good condition after eight years.

In areas such as Cataby, competition over nest sites is a significant current and ongoing threat to the survival of Carnaby's Cockatoo in this area. It is apparent that Carnaby's

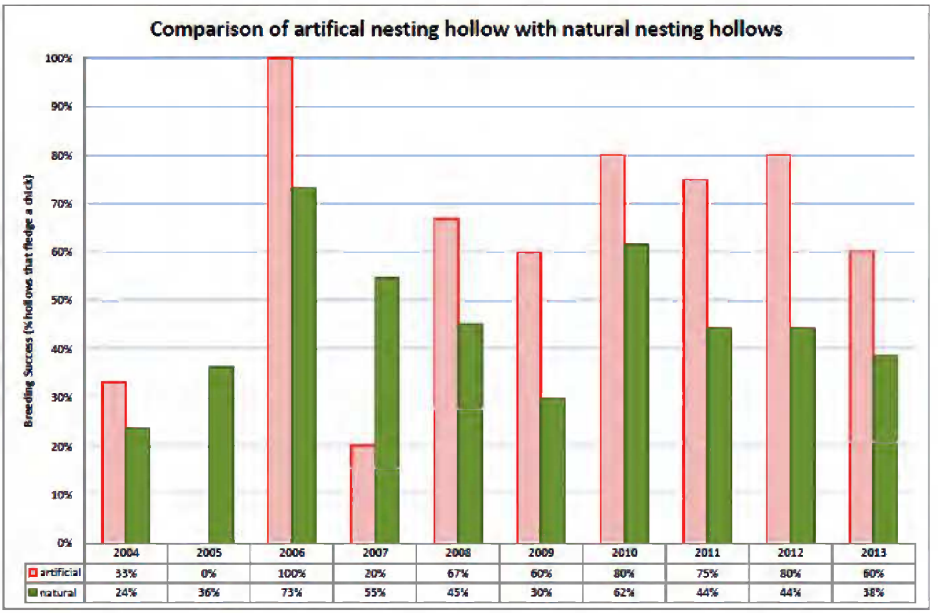

Figure 6. Comparison of artificial nest hollows (wooden boxes and PE tubes) with natural nest hollows 2004–2013

Cockatoo fair badly when competing with Galahs, Butler's Corellas and to a lesser degree some ducks including Australian Shelduck, Australian Wood Duck and Grey Teal. The populations of the "pest" species Galah and Butler's Corella and the feral European Honeybee are expected to increase unless there is management intervention to control these species.

In this study we found that top entry hollows were generally unattractive to feral European Honey bees as they do not like rain on the comb and do not like attaching comb to the PE walls.

The development and testing of various types of artificial nest boxes and tubes, the problems associated with competition, the solutions to these problems, checked by long-term monitoring can now lead to more efficient and effective economic use of resources in this field.

Judging from this study it is clear that the PE poly tubes specifically designed for black cockatoos, provide an extremely effective nest hollow and improve breeding success (Figure 6). Furthermore they are unattractive to feral Honeybees (due to open top allowing rain to enter) and to both Galahs and Butler's Corellas (that also do not favour top entry hollows). In areas such as Cataby with huge competition for hollows and the quality/availability of hollows declining the artificial tubes are an attractive offset for the loss of trees that may be lost due to storms, fire or clearing activity.

ACKNOWLEDGEMENTS

We would like to thank Iluka Resources for providing financial and material support for this project and for allowing access to Iluka properties.

REFERENCES

JOHNSTONE, R.E. and STORR, G.M. 1998. *Handbook of Western Australian Birds. Volume I — Non-passerines (Emu to Dollarbird).* Western Australian Museum, Perth, Western Australia.

JOHNSTONE, R.E. and KIRKBY, T. 2007. Feral European Honey Bees: a major threat to cockatoos and other tree hollow users. *The Western Australian Naturalist* **25**: 252–254.